Chapter 9
Repair of FRP Composites

9-1. General

As with any construction material, FRP composites are subject to damage. This damage may be intentional or unintentional. Intentional damage can occur when the composite components or structures are cut, drilled, or otherwise manipulated during installation or fabrication of the structure. Unintentional damage can be caused by accidental impact, unexpected excessive loading, or long-term environmental exposure. It is important to note that any damage or alteration to the fibers and/or the resin matrix may alter the performance properties (e.g., corrosion resistance and mechanical strength) of the composite component. The following information addresses the repair of composite materials needed as a result of damage or deterioration due to installation procedures, accidental damage, or environmental exposures.

9-2. Routine Maintenance

a. A properly designed and fabricated composite system will generally not require much in the way of routine maintenance. For aesthetic purposes, soil and other similar surface contaminants may be washed off using plain water [including steam cleaning at 120 °C (250 °F) maximum] or a detergent solution. Greases and oils may require cleaning with an appropriate organic solvent (i.e., one that will not attack the resin system).

b. Composites intended for direct exposure to weathering and ultraviolet radiation generally have a surface coating to improve corrosion and ultraviolet resistance. Under long-term weathering, especially if the original coating was too thin, fiber blooming (i.e., the emergence of fibers onto the surface) can occur. If left unattended, fiber bloom can lead to reduced corrosion resistance and eventual degradation of mechanical properties.

c. If fiber bloom is identified, the damaged area must be resealed with a resin-rich layer. The damaged area must be lightly sanded and cleaned to ensure proper adhesion of the sealant. Catalyzed resins or paints (e.g., polyester, epoxy, or polyurethane) may be used. A general rule is to use a sealant material type that is the same type as on the component being repaired. Acrylic lacquer or oil base paints can also be used but will probably not provide the same level of corrosion resistance as a catalyzed resin system. As required when using any chemical system, manufacturer's instructions must be closely followed to provide an optimum repair and to minimize the exposure to potentially hazardous materials.

9-3. Repair During Installation

Sawing, drilling, grinding, routing, and other such procedures may be necessary to accomplish installation or fabrication of the composite structure. Any such procedures that cut through the resin surface sealant, or otherwise expose the reinforcement fibers, can significantly reduce the corrosion resistance of the composite system. The exposed new surface must be appropriately sealed, basically as described in paragraph 9-2. To help ensure a proper repair, residual dust or other debris resulting from the installation operations must be thoroughly removed prior to the repair procedures. For installation operations that require the cutting of reinforcement fibers (e.g., drilling holes), review the guidance presented in paragraph 7-4.

9-4. Repairs Due to Accidental Damage and/or Service Exposures

Damage to the composite component can result from impact of falling or flying objects, unexpected excessive loading(s), handling of the composite during transportation, and installation or degradation (e.g., blistering) due to service exposures. The basic steps listed below should be followed regarding repair of the damaged area:

Step 1. Identify the extent of the damaged area.

Step 2. Assess the repair options:

a. Use as is.

b. Repair existing component.

c. Scrap and replace component.

Step 3. Accomplish the repair operation as required.

Step 4. Evaluate the repair.

a. Visual inspection will be the most often used method in locating damage on civil structures. Such visual inspections should be performed on a routine, periodic basis so damaged areas can be repaired before further deterioration to the composite component occurs. Ultrasonic and various other NDE methods are available to detect hidden damage as described in paragraph 8-2*c*.

b. Once the damage is detected/located and the extent of the damage determined, damage repair options must be considered. If the damage is exposed but is only a surface scratch or abrasion, the repair may be as simple as coating the area with a resin-rich coating as previously described. If hidden damage is detected and it is determined that the damaged area is not a critical load-bearing component, an assessment must be made as to whether the damaged area is likely to grow, thus warranting an immediate repair. If a repair is determined to be unwarranted at the time, the damaged area should still be monitored to assess possible growth of the damage to adjacent areas.

c. Damage to critical structural components will require immediate repair action. Basic repair options include:

(1) Patching with composite plates or overlays.

(2) Removing the damaged area or component and replacing with new material.

d. Localized minor cracks and punctures may be repaired using lay-up procedures similar to automotive body repair. The damaged area must first be sanded to roughen the surface. Lightly sand the surface 50-75 mm (2-3 in.) beyond the immediate damaged area. A fiber mat shall be cut to cover within 13 mm (1/2 in.) of the edge of the sanded area. Thoroughly wet the fiber mat with a catalyzed resin system compatible with the composite component being repaired. Multiple layers may be applied as needed. After curing, sand the area to a smooth finish and seal as described in paragraph 9-2.

e. If the extent of damage warrants the application of a plate to bridge over the damage area, the repair procedure will be similar to the procedures for making composite joints as described in paragraph 7-4. The patch plate can be bolted on, bonded on, or bonded and bolted on, as required.

f. If the extent of damage is considered beyond just applying a patch, the damaged section will need to be removed. The removed section may then be replaced with a new section or component. This may be as simple as bolting on a new beam or angle, or may require the laminating in of a new composite section. To ensure equal mechanical performance, the repair section must have the same fiber architecture (orientation and arrangement) and section thickness as the removed section.

9-5. Prepreg Kits

Composite prepreg systems are available as off-the-shelf repair kits for composite laminate systems. These kits were originally developed for field repair of composite components on aircraft. Most of these prepreg kits require the use of special equipment to provide heat and vacuum at the point of repair. Unless such repairs are expected to be made on a routine basis, purchase of the equipment and stockpiling of the prepreg kits (which have a limited shelf life) are probably not economical.

9-6. Underwater Repairs

Emergency situations or other site conditions may make it impossible to dewater or remove the composite structure from submersion in order to accomplish a repair. Under such circumstances, specially formulated resin systems and special procedures must be used for an underwater repair. Except for the repair of relatively minor damage, expert advice should be sought before attempting any major underwater repair procedures. The nonideal conditions of performing underwater repairs call for a high level of quality control during the repair process. Under most circumstances, underwater repairs should be viewed as a temporary measure until such time that permanent repairs in dry conditions can be made.

9-7. Special Considerations

a. For any repair procedures (whether part of routine maintenance or due to intentional or unintentional damage) involving the application of liquid or semicured resins, the following items must be accomplished:

(1) The surface to be repaired must be thoroughly cleaned and appropriately roughened.

(2) The fiber reinforcement mat must be thoroughly wetted with resin (already wetted with resin in prepreg systems).

(3) The catalyzed resin system must be completely mixed in the exact proportions indicated on the product container. Incorrect proportions or incomplete mixing can cause improper cure. Improper curing may result in significantly reduced mechanical and corrosion-resistant properties.

(4) Temperature extremes can adversely affect resin curing. As ambient temperatures rise, the working time of the resin mix will decrease. To increase the working time on very hot days (27 °C (80 °F) plus), the liquid resin components may need to be cooled in a refrigerator before mixing. Problems can also result when the ambient temperatures are too cold. For typical catalyzed resin systems, improper cure may result if temperatures go below 10 °C (50 °F) anytime during the first 24 hours after applying. Special catalyzed systems can be used for low temperature applications. Applying heat so the item and the surrounding air temperature are maintained above the minimum for a 24-hour period is another alternative.

(5) Handle all liquid repair materials and components with extreme care to minimize exposure to possible hazardous/toxic chemicals. Also be sure to properly dispose of all unused repair component materials.

(6) In all of the procedures presented above, carefully follow any manufacturer's directions to best ensure a successful and safe repair.

b. If there are any questions concerning damage assessment or how to accomplish an appropriate repair, seek out the advice of the composite component/system manufacturer or other expert familiar with composite damage assessment and repair.